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ABSTRACT

AIM: This study evaluated the effectiveness of different treatment modalities for deep bite correction in adult patients, focusing on anterior teeth intrusion, clinical outcomes, and long-term stability to inform evidence-based treatment planning.

METHODS: A structured literature review was conducted using PubMed and Google Scholar, selecting 26 studies published between 2010 and 2025. Inclusion criteria prioritised adult, non-growing patients and clinical evaluations of deep bite correction. Key variables included incisor intrusion, inclination changes, and the incidence of external apical root resorption (EARR).

RESULTS: Multiple modalities—fixed appliances, intrusion arches, temporary anchorage devices (TADs), clear aligners, bite turbos, functional appliances, and surgical interventions—were effective for adult deep bite correction. Two-TAD configurations placed distal to the lateral incisors achieved the highest intrusion with superior torque control and proclination-to-intrusion ratios as low as 0.6°/mm. Intrusion arches produced notable intrusion but greater labial proclination. EARR was consistently observed across all modalities involving anterior intrusion, with its extent strongly influenced by intrusion rate and incisor proclination.

CONCLUSION: Various methods effectively correct deep bites in adults. Appropriate modality selection requires an understanding of each method's biomechanical forces and alignment with the patient's malocclusion. Most intrusion-based treatments involve incisor proclination, making the proclination-to-intrusion ratio a key metric for clinical decision-making and long-term planning.

Keywords: Deep bite correction; Adult orthodontics; Anterior intrusion; Temporary anchorage devices

1. Introduction

Deep bite, clinically defined as an excessive vertical overlap between the upper and lower anterior teeth, represents one of the most prevalent forms of malocclusion in both paediatric and adult populations (Proffit et al., 2018). When left untreated, deep bite may lead to a variety of functional and physiological complications, including impaired mastication, speech disturbances, temporomandibular joint (TMJ) dysfunction, and aesthetic concerns, particularly in adult patients (Watted et al., 2023).

A range of treatment modalities has been developed to address deep bite malocclusion. These include extrusion of posterior teeth, intrusion of anterior teeth, a combination of both, proclination of incisors, and, in more severe cases, orthognathic surgery (Daokar & Agrawal, 2016). Among these, anterior teeth intrusion has emerged as the preferred strategy in non-growing individuals due to its biomechanical predictability and the relative stability of treatment outcomes (Varlik et al., 2013). Techniques frequently employed to achieve anterior intrusion include the use of utility arches, segmented intrusion arches, and mini-screw anchorage systems (Daokar & Agrawal, 2016).

Although early intervention during the growth period typically yields more favourable and stable treatment results (Huang et al., 2012), such opportunities are not universally accessible. In many countries with comprehensive healthcare systems, orthodontic treatment during childhood is commonly supported through health insurance, enabling early correction of malocclusions such as deep bite. By contrast, in several Asian countries, orthodontic care is often excluded from public insurance coverage, placing the financial burden directly on individuals and leading to postponed treatment in adulthood. In addition to socioeconomic factors, racial variations in the prevalence of deep bite have also been documented, with a higher mean prevalence observed among Caucasians compared to other population groups (Alhammadi et al., 2018).

The correction of deep bite in adult patients presents distinct clinical challenges. Unlike growing patients, adults cannot benefit from skeletal growth to facilitate bite correction. As a result, posterior extrusion becomes less viable, and treatment must instead rely on controlled anterior intrusion (Daokar & Agrawal, 2016). This approach necessitates precise biomechanical control to minimise risks such as external apical root resorption and relapse. Skeletal morphology, particularly in hypodivergent individuals, may further complicate treatment by limiting vertical development in the posterior region (Daokar & Agrawal, 2016). In cases involving significant skeletal discrepancies, surgical intervention may be required to achieve satisfactory functional and aesthetic outcomes (Daokar & Agrawal, 2016; Watted et al., 2023).

The objective of this thesis is to systematically evaluate the effectiveness of various treatment modalities for the correction of deep bite in adult patients, with an emphasis on anterior teeth intrusion. By assessing clinical outcomes and long-term stability, this study aims to contribute to evidence-based clinical decision-making and enhance the standard of orthodontic care in adult populations.

The aim of this study is to systematically evaluate the effectiveness of different orthodontic treatment modalities for deep bite correction in adults, focusing on anterior teeth intrusion, and to assess their clinical outcomes and long-term stability.

2. Methods

The literature review for this review utilised the PubMed and Google Scholar databases. The search strategy was established using the population, intervention, comparison, and outcome (PICO)

methodology. PICO was employed to develop keywords and optimise the procedure for searching for the complete set of relevant articles.

The population consisted of adult patients with deep bite malocclusion, specifically non-growing patients in the post-pubertal growth period aged 18 years and above. The interventions included various treatment options, such as fixed appliances (e.g., buccal/lingual appliances, utility arches, reverse curve of Spee wires), clear aligners with attachments or specific deep bite correction protocols, anterior or posterior bite planes, skeletal anchorage devices (TADs) for intrusion, intrusion arches, surgical interventions, or combinations thereof. These treatment modalities were compared against one another. The primary outcome measure was the reduction of overbite, assessed via clinical examination, pre- and post-treatment lateral cephalometric X-ray, or model analysis, alongside other outcomes affecting deep bite correction.

In accordance with the inclusion criteria, studies were considered if they involved participants aged 18 years or older who either were not experiencing growth, were in the post-pubertal growth phase, or had already reached their peak growth. Furthermore, the studies needed to evaluate the efficacy or treatment outcomes associated with the correction of deep bite malocclusion, provide information on the post-treatment stability outcomes, investigate any side effects following the correction of deep bite malocclusion, and examine the use of combined or multiple treatment modalities for deep bite correction.

Conversely, studies were excluded if they primarily focused on syndromes or craniofacial anomalies associated with deep bite rather than isolated deep bite malocclusion. The selection process also ruled out studies that included patients with significant systemic diseases that could potentially impact orthodontic treatment outcomes or bone metabolism. Additionally, studies utilising treatment protocols that were not clearly described or were deemed irrelevant to current clinical practice were excluded, alongside case reports, case series with fewer than 10 participants, editorials, letters to the editor, or reviews lacking original data. Further exclusion criteria included studies published in languages other than English, those that did not provide adequate data on the outcomes of interest, animal or in vitro studies, and narrative reviews, as well as samples categorised as growing patients.

The titles and abstracts of the retrieved studies were initially screened based on predefined inclusion and exclusion criteria. Full-text articles of potentially relevant studies were subsequently reviewed in detail. Studies were excluded at this stage if they did not contain sufficient data or were not aligned with the objectives of the review. The study selection process is illustrated in the PRISMA flow diagram (**Figure 1**).

From the eligible studies, the following data were extracted: names of the authors, year of publication, sample size in both treatment and control groups, mean age of participants, and study duration. Additional extracted data included the intervention, the type of malocclusion treated, and the method of evaluation.

This process resulted in the identification of studies that met the inclusion criteria and were suitable for qualitative synthesis. The following chapter presents the characteristics of these studies and summarises their findings in relation to the treatment outcomes of deep bite correction in adults.

2.1. Statistics

Descriptive statistics, frequency analysis, and content analysis were employed as part of the qualitative methodology to systematically analyze the textual content of the included studies. It is

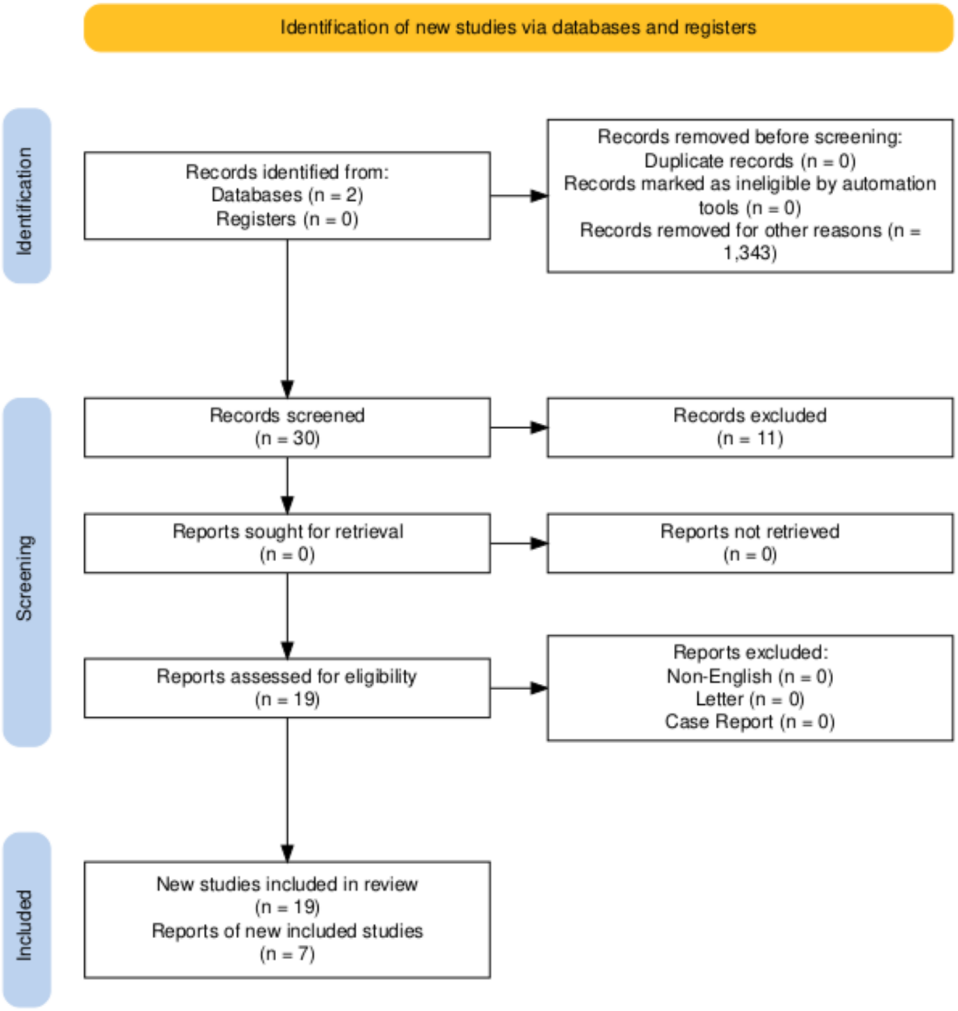

Figure 1. PRISMA flow diagram illustrating the study selection process.

important to note that, given the narrative nature of this study, regression analysis and meta-analysis techniques were not deemed suitable for the analytical framework.

3. Results

3.1. Study selection and characteristics

A thorough literature review was conducted using PubMed and Google Scholar, encompassing publications from 2010 to 2025. The search employed various combinations of keywords and Boolean operators (AND/OR) to gather comprehensive information relevant to the research question specified in this thesis, resulting in an initial total of 1,373 records. After applying specific filters related to article type, excluding case reports, books, and letters, 1,343 records were excluded from consideration. Subsequently, the titles and abstracts of the remaining 30 records were screened. All 30 full-text records were assessed, and 11 articles were excluded based on the inclusion and exclusion criteria, leaving 19 studies from the initial database search. Additionally, a hand search of

relevant reference lists identified seven further eligible studies. Ultimately, a total of 26 studies were selected for detailed analysis.

The studies investigating deep bite correction predominantly involved adult participants, with some studies including post-pubertal adolescents. A variety of treatment modalities were assessed, including fixed appliances, intrusion arches, miniscrews (TADs), clear aligners, bite turbos, functional appliances, and surgical approaches. Most participants presented with Class I or Class II malocclusion, and deep bite was typically defined as an overbite of 4 mm or greater. Treatment durations ranged from a few months to several years, depending on the specific intervention. Commonly used measurement tools included lateral cephalograms, CBCT imaging, dental models, and digital analysis software.

3.2. Effectiveness of Various Treatment Modalities for Deep Bite Correction in Adults

The biomechanical forces and clinical effects of different treatment modalities for adult deep bite correction, including the direction and magnitude of intrusion (INT), extrusion (EXT), and inclination (INC) on the upper (U1, U6) and lower (L1, L6) teeth, are summarised in **Table 1**.

Fixed appliances (FApp.), both labial and lingual, are commonly and effectively used in deep bite correction. Labial appliances intrude the upper incisors (U1) but are often associated with greater labial proclination, minimal L1 extrusion, and increased proclination of L1, along with mesial tipping of L6. Lingual appliances, by contrast, provide greater U1 intrusion and better control over incisor inclination. They also result in greater U6 extrusion, L1 intrusion with minimal labial tipping, and distal tipping of L6. Overall, lingual systems minimise labial flaring, offer better biomechanics for managing adult deep bite cases, and are particularly effective in facilitating bite opening.

Intrusion arches, such as the Burstone and K-Sir loops, reliably produce maxillary incisor (U1) intrusion but are often accompanied by labial proclination, extrusion, and distal tipping of the maxillary molars (U6). The Connecticut Intrusion Arch (CIA) achieved 2.2 mm of U1 intrusion with no recorded proclination. Conventional intrusive arches (Con.) generally produce U1 intrusion with proclination but without U6 extrusion.

Reverse curve of Spee (RCOS) archwires also contribute to deep bite correction by generating L1 intrusion and proclination, as well as distal tipping of L6, thereby improving vertical control when used in conjunction with fixed appliances.

TADs (miniscrews) have demonstrated high effectiveness in achieving maxillary incisor (U1) intrusion and reducing incisor proclination, particularly when two TADs are employed. These devices provide concentrated and well-controlled intrusive forces. A two-TAD system offers improved force distribution, resulting in less labial inclination of the incisors compared with single-TAD setups. Notably, TAD-assisted maxillary anterior intrusion has also proven effective in simultaneously correcting both a gummy smile and deep bite, yielding both functional and aesthetic benefits. Additionally, TADs have minimal impact on molar inclination or extrusion, thereby preserving the posterior vertical dimension. These findings support the clinical utility of TADs in adult deep bite correction, particularly when two-point anchorage is used to enhance control over incisor tipping.

Clear aligners (InvG5) produced 0.9 mm of U1 intrusion and 1.3 mm of L1 intrusion, with no significant molar movement. This demonstrates moderate vertical control and effective inclination preservation, making aligners suitable for mild to moderate deep bite cases. While aligners provide better control over incisor inclination compared with labial appliances, multiple refinement stages are often necessary to achieve optimal outcomes.

Table 1. Summary of Biomechanical Orthodontic Effects (BOF) Across Different Treatment Modalities.

METHODS	TYPE	BOF INT (MM)	BOF INC (°)	BOF EXT (MM)	BOF INC (°)	BOF INT (MM)	BOF EXT (MM)	BOF INC (°)	BOF EXT (MM)	BOF INC (°)
Tooth	N/A	U1	U1	U6	U6	L1	L1	L1	L6	L6
FApp.	Buccal	0.6	6.7	N/A	N/A	0.5	N/A	N/A	0.3	9.7
FApp.	Lingual	1.1	0.2	N/A	N/A	1.1	N/A	1.0	N/A	1.2
Int. Arch	Burstone	4.3	10.9	N/A	N/A	4.2	4.9	N/A	N/A	N/A
Int. Arch	K-SIR	1.9	N/A	0.5	N/A	N/A	N/A	N/A	N/A	N/A
CIA	N/A	2.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Con. Int. Arch	N/A	2.9	7.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RCOS in Md.	NiTi/SS	N/A	N/A	N/A	N/A	1.0	N/A	2.9	N/A	N/A
RCOS in Md.	TAD	One	5.7	14.3	N/A	N/A	N/A	N/A	N/A	N/A
RCOS in Md.	TAD	Two	8.2	11.5	N/A	N/A	N/A	N/A	N/A	N/A
Aligner	InvG5	0.9	N/A	0.4	N/A	1.3	N/A	N/A	0.6	N/A
BT	IBT	0.5	1.6	N/A	N/A	0.5	N/A	1.0	N/A	4.5
BT	N/A	0.8	N/A	N/A	N/A	0.7	N/A	0.7	N/A	3.8
Herbst	CBJ	N/A	N/A	2.4	Pa	N/A	N/A	N/A	3.5	N/A
Herbst	N/A	N/A	N/A	N/A	N/A	M	N/A	N/A	N/A	N/A

Note: BT: Bite Turbos, Burstone: Burstone Intrusion Arch, CBJ: Cantilever Bite Jumper, CBT: Canine Bite Turbos, CIA: Connecticut Intrusion Arch, Con. Int. Arch: Conventional Intrusion Arch, D: Distal, EXT (mm): Extrusion (millimeters), FApp.: Fixed Appliance, IBT: Incisor Bite Turbos, INC (°): Inclination (degrees), INT (mm): Intrusion (millimeters), InvG5: Invisalign G5 with Precision Bite Ramp, K-SIR: K-SIR Intrusion Arch, La: Labial, L1: Lower Incisors, L6: Lower First Molars, M: Mesial, NiTi: Nickel Titanium Wire, Pa: Palatal, RCOS: Reverse Curve of Spee, SS: Stainless Steel Wire, TAD: Temporary Anchorage Device (Miniscrew), U1: Upper Incisors, U6: Upper First Molars, (°) Degrees, mm: Millimeters, NA: Data not reported.

Bite turbos, particularly anterior bite turbos (IBT) and canine bite turbos (CBT), support deep bite correction by promoting incisor intrusion and extrusion of posterior teeth. IBTs tend to cause more labial tipping of L1, whereas CBTs offer better inclination control. IBT and CBT produced U1 intrusion (0.5 mm and 0.2 mm, respectively) with mild proclination. Both types also caused L1 proclination (4.5° for IBT and 3.8° for CBT) and slight molar extrusion, supporting their use as adjunctive tools when combined with fixed appliances.

Functional appliances, such as the Herbst CBJ appliance, are primarily used in post-pubertal adolescents, with a reported mean age range of 16.37–18.89 years. In adult patients, where skeletal growth has ceased, the Herbst appliance exerts limited skeletal effects and primarily induces dental

movements, including mesial tipping of the mandibular first molars (L6), labial proclination of the mandibular incisors (L1), and palatal inclination of the maxillary incisors (U1). Specifically, the Herbst CBJ appliance has been shown to cause 2.4° of palatal inclination in U1 and mesial tipping of L6. Owing to these dentoalveolar effects, the Herbst CBJ appliance is considered effective for deep bite correction in post-pubertal adolescents, particularly when used in combination with fixed appliances.

Surgical approaches, particularly bilateral sagittal split osteotomy (BSSO) for mandibular advancement, are generally indicated for adult patients presenting with severe skeletal deep bite discrepancies. Although this modality is not included in **Table 1**, which summarises the biomechanical characteristics of orthodontic interventions, its clinical outcomes are well documented in the literature. Surgical correction typically results in an average overbite reduction of approximately 3.4 mm, accompanied by stable occlusal outcomes and minimal dental side effects. Nevertheless, postoperative skeletal relapse has been reported in approximately 25% of cases. Despite this potential for relapse, surgical intervention remains a highly effective treatment option in non-growing patients where orthodontic correction alone may be insufficient to achieve the desired skeletal and functional improvements.

In conclusion, while all modalities contribute to deep bite correction in adults, their effectiveness varies based on biomechanics, force application, and patient-specific needs. TADs and lingual fixed appliances provide superior incisor intrusion with excellent control over inclination, making them ideal for cases requiring precise vertical and axial correction. Intrusion arches and labial appliances offer predictable intrusion but are associated with greater proclination and molar extrusion. Clear aligners provide moderate improvement with better aesthetic control, although they often require refinements. Bite turbos serve as valuable adjuncts, and functional appliances have limited applications in non-growing patients. Surgical correction remains the most effective approach for cases involving severe skeletal discrepancies. This underscores the importance of selecting treatment modalities based on a careful balance between clinical efficiency and the unique characteristics of each patient.

3.3. Effects of TADs and Intrusive Mechanics on Incisor Intrusion and Inclination

As established in the previous chapter and summarised in **Table 1**, temporary anchorage devices (TADs) and intrusion arches demonstrated the highest levels of maxillary incisor (U1) intrusion among all treatment modalities evaluated. Owing to their significant intrusive capabilities, which distinguish them as particularly effective tools for managing deep bite malocclusion in adults, a focused comparison of these two approaches is warranted. A dataset from selected studies investigating TADs and intrusion arches, reporting specifically on maxillary incisor intrusion (U1-PP in millimetres) and proclination (U1-PP in degrees), was used to calculate the ratio of proclination to intrusion. This ratio (°/mm) offers a more refined assessment of each method's biomechanical efficiency (**Table 2**).

Although heterogeneity exists among the included studies, including differences in wire types, applied forces, TAD positions, and methodological design, several consistent patterns were observed. A universal finding is that incisor intrusion is never achieved in isolation, it is invariably accompanied by a change in inclination, typically labial proclination. This suggests that proclination is not merely an unwanted side effect but an intrinsic component of the biomechanical process of anterior intrusion. As such, the ability to manage proclination is a critical consideration when selecting or designing an intrusion protocol.

Table 2. Comparison of TAD and Intrusive Mechanics: Effects on Incisor Intrusion and Inclination.

AUTHOR (YEAR)	METHOD	LOCATION	ARCHWIRE/TAD SIZE	U1-PP (°) A	U1-PP (MM) B	RATIO A:B (°/MM)
Raj (2015)	Two TADs	Distal to 2LI	-	2.7	4.4	0.6
Namrawy (2019)	Two TADs	Distal to 2LI	Ø1.4, 6 mm	2.3	2.9	0.8
Vela-Hernández (2020)	Two TADs	Distal to 2LI	Ø1.6, 8 mm	11.5	8.2	1.4
Vela-Hernández (2020)	One TAD	Bet. CI	Ø1.6, 8 mm	14.3	5.7	2.5
Raj (2015)	Burstone	4I	0.017″x0.025″ SS	10.9	4.3	2.5
Namrawy (2019)	Con. Int.Arch	4I	0.017″x0.025″ TMA	7.9	2.4	3.3
Goel (2014)	K-SIR	4I	0.017″x0.025″ TMA	5.7	1.3	4.4
Goel (2014)	Rickets Utility	4I	0.017″x0.025″ TMA	8.2	1.6	5.1

Note: A or U1-PP (°): Amount of Maxillary Incisor Proclination (degrees), B or U1-PP (mm): Amount of Maxillary Incisor Intrusion (millimeters), Bet.: Between, Burstone: Burstone Intrusion Arch, CI: Upper Central Incisors, Con. Int. Arch: Conventional Intrusion Arch, K-SIR: K-SIR Intrusion Arch, Ratio A:B (°/mm): Ratio of Proclination to Intrusion (degrees/millimeter), SS: Stainless Steel Wire, TAD: Temporary Anchorage Device (Miniscrew), TMA: Titanium-Molybdenum Alloy Wire, Y: Years, 2LI: Upper Lateral Incisors Bilaterally, 4I: Four Upper Incisors, : Inches, mm: Millimeters, °: Degrees, Ø: Diameter, –: Data not reported.

Some studies were excluded from direct ratio comparison owing to insufficient or incompatible data. For example, Almeida et al. (2018) compared straight wire mechanics with a Connecticut Intrusion Arch but reported only intrusion values without inclination data. Verma and Jain (2020) investigated TADs and the K-SIR loop in a premolar extraction case, but their results showed retroclination, reflecting a different biomechanical context, and were thus excluded. Additionally, data from Manikandan et al. (2024) were excluded owing to suspiciously low intrusion values (0.5–0.7 mm), suggesting potential methodological inconsistencies.

3.3.1. Intrusion Arch Mechanics

Among studies investigating intrusion arch mechanics, the Burstone intrusion arch (Raj et al., 2015) demonstrated the most favourable ratio of proclination to intrusion, 10.9° of proclination over 4.3 mm of intrusion, resulting in a ratio of 2.5°/mm. This was followed by the conventional intrusion arch (7.9°/2.4 mm, 3.3°/mm) and the K-SIR loop (5.7°/1.3 mm, 4.4°/mm). The Ricketts utility arch (Goel et al., 2014) yielded the least favourable ratio among the intrusion arch group, 8.2° of proclination for 1.6 mm of intrusion, corresponding to a ratio of 5.1°/mm.

3.3.2. TAD-Based Mechanics

TAD-supported intrusion methods demonstrated a broader range of outcomes. The most efficient ratio was observed in Raj et al. (2015), where a two-TAD configuration placed distal to the lateral incisors resulted in 2.7° of proclination for 4.4 mm of intrusion, yielding a favourable ratio of 0.6°/mm. Similarly, Namrawy et al. (2019) reported a two-TAD configuration in the same placement, which produced 2.3° of proclination for 2.9 mm of intrusion, corresponding to a ratio of 0.8°/mm, only slightly less favourable than that reported by Raj et al. (2015). In contrast, Vela-Hernández et al. (2020) documented a two-TAD setup that resulted in 11.5° of proclination

with 8.2 mm of intrusion (1.4°/mm), while the one-TAD group in the same study demonstrated the least favourable TAD-based ratio, 14.3° of proclination for 5.7 mm of intrusion, or 2.5°/mm. Notably, Vela-Hernández et al. (2020) with one TAD and Raj et al. (2015) with the Burstone intrusive arch both exhibited an identical proclination-to-intrusion ratio of 2.5°/mm. However, the mechanics differ in character, the one-TAD setup produced a higher amount of both intrusion (5.7 mm vs. 4.3 mm) and proclination (14.3° vs. 10.9°) compared with the Burstone arch. This comparison highlights that despite similar ratios, the absolute magnitude of movement, and associated side effects, may vary considerably depending on the modality used.

3.3.3. Comparison Across Modalities

Proclination values across all modalities ranged from as low as 2.3° with two TADs (Namrawy et al., 2019) to as high as 14.3° with a single TAD (Vela-Hernández et al., 2020). As an indirect indicator of torque control, lower proclination values suggest more effective anchorage and reduced labial tipping. Notably, two-TAD configurations placed distal to the lateral incisors consistently resulted in lower proclination and more favourable proclination-to-intrusion ratios, underscoring their superiority in torque management. In contrast, one-TAD setups, particularly those positioned between the central incisors, were associated with significantly greater proclination per unit of intrusion.

Among intrusion arches, the Burstone system provided the most balanced biomechanical outcome, achieving substantial intrusion with relatively minimal proclination. By comparison, the Ricketts utility arch exhibited the highest degree of proclination per millimetre of intrusion, rendering it less suitable in clinical scenarios where torque control is a primary concern.

3.3.4. Clinical Implications

These findings emphasise the biomechanical challenge of achieving pure incisor intrusion without inducing excessive labial tipping. Given that every instance of intrusion involves a change in inclination, evaluating the proclination-to-intrusion ratio offers a clinically relevant metric for treatment planning. In general, a lower ratio (°/mm) indicates more biomechanically efficient intrusion with less undesired tipping, which is especially important in adult patients where aesthetic demands and periodontal risks are heightened.

3.3.5. Summary of Findings

Both TAD-based and intrusion arch mechanics are effective for incisor intrusion in adult deep bite correction. However, they differ significantly in their impact on incisor inclination. TADs, particularly in dual configurations placed distal to the lateral incisors, provide superior control over proclination and produce the most favourable ratios. Intrusion arches, while effective in generating intrusion, tend to induce more proclination, making them less suitable in cases where root control is paramount. These results underscore the importance of tailoring intrusion protocols to individual patient needs, balancing the depth of intrusion with torque control to ensure stable, aesthetic, and biologically sound outcomes.

3.4. External Apical Root Resorption in Relation to Intrusion Rate and Incisor Proclination

As established in Chapters 3.2 and 3.3, both temporary anchorage devices (TADs) and intrusion arches demonstrated the highest levels of maxillary incisor (U1) intrusion among all evaluated

treatment modalities. Given the mechanical demands and biological stress placed on the tooth roots during such movements, external apical root resorption (EARR) emerges as an important and likely unavoidable treatment consideration in adult deep bite correction. **Table 3** presents a comparative summary of intrusion force, duration, rate, and incisor proclination across studies, along with the associated levels of EARR observed in central (CI) and lateral incisors (LI).

Table 3. Comparison of EARR According to Intrusion Rate and Incisor Proclination Across Different Intrusion Methods.

AUTHOR (YEAR)	METHOD	LOCATION	ARCHWIRE/TAD SIZE	U1-PP (°) A	U1-PP (MM) B	RATIO A:B (°/MM)
Raj (2015)	Two TADs	Distal to 2LI	-	2.7	4.4	0.6
Namrawy (2019)	Two TADs	Distal to 2LI	Ø1.4, 6 mm	2.3	2.9	0.8
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Goel (2014)	K-SIR	4I	0.017″x0.025″ TMA	5.7	1.3	4.4
Goel (2014)	Rickets Utility	4I	0.017″x0.025″ TMA	8.2	1.6	5.1

Note: Ant.: Anterior, CIA: Connecticut intrusion arch, CI: Upper central incisor, Con.: Conventional leveling and alignment, EARR: External apical root resorption, Int. Duration: Intrusion force duration (months), Int. Force: Intrusion force (grams), Int. Rate: Intrusion rate (millimeters/month), IP (°): Incisor proclination (degrees), K-SIR: K-SIR intrusion arch, L: Lower arch, LI: Upper lateral incisor, Post.: Posterior, RCOS: Reverse curve of Spee, TAD: Temporary anchorage device (miniscrew), U: Upper arch, Y: Years, M.: Months, mm: Millimeters, (°): Degrees, –: Data not reported.

Root resorption was consistently observed across all treatment modalities involving anterior intrusion. Even conventional archwires (Almeida et al., 2018), which employed relatively moderate forces and produced minimal tipping, still showed measurable EARR in both central and lateral incisors (0.48 mm and 0.56 mm, respectively), confirming that intrusion itself is a key contributing factor.

Across both TAD-based and intrusion arch mechanics, a clear pattern emerged, higher intrusion rates were generally associated with increased EARR. This trend was evident in Goel et al. (2014), Gürlen et al. (2016), and Aras et al. (2016), where greater intrusion rates correlated with more extensive resorption in both central and lateral incisors. For instance, in Gürlen et al. (2016), the TAD group demonstrated a higher intrusion rate (0.49 mm/month) and greater root resorption (1.13 mm in CI, 0.81 mm in LI) compared to the CIA group (0.30 mm/month, 0.71 mm in CI, 0.55 mm in LI). A similar pattern was observed in Aras et al. (2016), where the anterior TADs with a higher rate of 0.62 mm/month resulted in greater resorption (1.25 mm in CI, 0.96 mm in LI) than the posterior TADs (0.39 mm/month, 0.90 mm in CI, 0.67 mm in LI).

Likewise, increased incisor proclination (IP), representing labial tipping, was generally associated with higher EARR. This was notably demonstrated in Goel et al. (2014), where the Ricketts utility arch caused the highest tipping (8.2°) and the greatest resorption among intrusion arches (1.56 mm in CI). In Gürlen et al. (2016), TADs led to more proclination (9.4°) and more resorption (1.13 mm in CI) compared to the CIA group (6.6°, 0.71 mm in CI). In Vela-Hernández et al. (2020), the one-TAD group displayed significantly greater proclination (14.3° vs. 11.5°) and correspondingly

more EARR in the central incisor (2.20 mm vs. 2.11 mm) than the two-TAD group. These findings support the interpretation that excessive tipping increases mechanical stress at the root apex, thereby heightening the risk of resorptive damage.

However, an exception was observed in Aras et al. (2016). Despite the posterior TAD group exhibiting higher incisor proclination (14.8°), it showed less EARR than the anterior TAD group. This unexpected outcome may be attributed to differences in force vector direction and TAD placement. The anterior TADs were positioned between the lateral incisors and canines, applying force with a more vertical component, which likely contributed to a higher intrusion rate and increased apical compression, factors known to elevate the risk of root resorption. In contrast, the posterior TADs, placed between the second premolars and first molars, delivered force with a greater horizontal component. This may have facilitated the retraction of the incisor roots into the spongiosa, a region of less dense bone, potentially reducing resorptive stress on the root apex.

Manikandan et al. (2024) further emphasised the impact of torque control. Although the two-TAD group achieved greater overall intrusion, the proclination angle was lower (3.6° vs. 4.3°), and central incisor resorption was also reduced (0.55 mm vs. 0.73 mm), reinforcing the importance of controlled force application.

It is also essential to recognise that heterogeneity in study methodologies, including differences in radiographic techniques, sample sizes, force magnitude and direction, treatment durations, and measurement protocols, limits the ability to make direct comparisons between studies. While the observed trends suggest that intrusion rate and incisor proclination are the most influential factors contributing to EARR during adult deep bite correction, these conclusions must be interpreted with caution. Further investigation through well-controlled, standardised clinical trials is needed to confirm these associations and guide evidence-based treatment planning.

In conclusion, external apical root resorption is a common and significant side effect of maxillary incisor intrusion in adult patients. The extent of EARR is influenced primarily by the intrusion rate and the degree of incisor proclination. Higher values of either parameter generally correspond to increased root resorption, although the direction of force application and torque control mechanisms may modulate this relationship. These results underscore the importance of selecting biomechanical strategies that balance efficient tooth movement with biological safety, particularly in treatment plans involving TADs or intrusion arches. Personalised protocols that limit excessive tipping and control the rate and direction of intrusion are essential for minimising EARR risk while achieving successful deep bite correction.

4. Discussion

The primary objective of this thesis was to systematically evaluate the effectiveness of various treatment modalities for deep bite correction in adult patients, with particular emphasis on anterior tooth intrusion. This investigation aimed to support evidence-based treatment planning and enhance biomechanical strategies tailored to adult orthodontic care. The following discussion interprets the findings within the context of the existing literature and current orthodontic knowledge.

A total of 26 studies published between 2010 and 2025 were selected for analysis. These findings demonstrate that numerous modalities, including fixed appliances, intrusion arches, temporary anchorage devices (TADs), clear aligners, bite turbos, functional appliances, and surgical interventions, can effectively address deep bite malocclusion in adults. Each method exerts orthodontic forces in distinct directions and magnitudes, thereby producing variable dental movements and biomechanical effects. As such, treatment selection should be guided by the desired clinical outcomes, the patient's

anatomical and occlusal characteristics, and the specific type of deep bite malocclusion present. Among the evaluated techniques, TADs and intrusion arches were shown to achieve the highest levels of maxillary incisor (U1) intrusion, highlighting their clinical value in cases requiring vertical correction.

4.1. Comparative Effectiveness and Biomechanical Considerations of Deep Bite Treatment Modalities in Adults

The effectiveness of various modalities in adult deep bite correction differs markedly depending on the biomechanical mechanism, the magnitude of correction achieved, and the degree of control over associated side effects.

Conventional labial fixed appliances are effective, but they often achieve overbite reduction primarily through significant incisor proclination, approximately 6.7° for U1, accompanied by only modest intrusion, approximately 0.6 mm for U1. This pattern of correction may be suboptimal in adult cases that require precise torque control or in patients for whom labial flaring is undesirable. In contrast, lingual fixed appliances offer more favourable torque management, providing controlled maxillary incisor intrusion, approximately 1.1 mm for U1, with minimal proclination, approximately 0.2°. Additionally, they promote greater extrusion of the maxillary first molars (U6, approximately 1.1 mm) and intrusion of the lower incisors (L1, approximately 1.0 mm), resulting in a bite-opening effect with minimal labial tipping. Lingual therapy is particularly suitable when lower incisor intrusion is desired and is preferred for patients presenting with proclined incisors at the outset of treatment, in whom further proclination is not indicated.

Intrusion arches, whether Burstone, K-SIR, CIA, or conventional designs, are highly effective in achieving substantial maxillary incisor (U1) intrusion, ranging from 1.9 mm to 4.3 mm. However, they are often associated with labial proclination, except for the Connecticut Intrusion Arch (CIA), which has not been reported to cause such tipping. Among these, the Burstone arch demonstrates the highest level of intrusion and proclination (4.3 mm / 10.9°). Additionally, these mechanics may lead to molar (U6) extrusion and distal tipping due to the posterior anchorage and the direction of force application, necessitating more rigorous anchorage control and careful monitoring of side effects.

Temporary anchorage devices (TADs) stand out for their remarkable effectiveness, achieving the greatest reported levels of maxillary incisor intrusion, up to 8.2 mm with two TADs. TADs deliver intrusive forces that are accompanied by labial proclination of the upper incisors (U1), however, torque control is significantly superior in two-TAD configurations compared with one-TAD setups. Additionally, TADs minimise molar side effects, thereby preserving the posterior vertical dimension, a biomechanical advantage that is particularly critical in non-growing adult patients.

Clear aligners offer moderate levels of intrusion, approximately 0.9 mm for U1, and better control of incisor inclination, making them suitable for mild-to-moderate cases in which aesthetics are prioritised. However, they often require multiple refinements to achieve optimal results because of their limited vertical force delivery.

Bite turbos and reverse curve of Spee (RCOS) wires function primarily as adjunctive mechanics, promoting bite opening through posterior tooth extrusion or lower incisor intrusion and proclination. These methods are useful for facilitating vertical correction, but they should be paired with other modalities for comprehensive control.

Functional appliances, such as the Herbst CBJ, have limited applicability in adult patients because of the absence of active skeletal growth. In the referenced study, participants were in

the post-pubertal stage of late adolescence, aged 16.37–18.89 years, a period generally considered beyond the pubertal growth peak. As a result, the effects of functional appliances at this stage are primarily dentoalveolar, including mesial tipping of the mandibular molars and labial proclination of the mandibular incisors, offering minimal skeletal modification. This limitation becomes even more pronounced in fully matured adults, who exhibit rigid occlusal relationships and significantly reduced potential for skeletal adaptation (Watted et al., 2023; Huang et al., 2012). In such cases, the ability of functional appliances to induce skeletal changes is greatly diminished, reducing their clinical effectiveness in managing deep bite cases with underlying skeletal discrepancies.

For severe skeletal deep bite cases, orthognathic surgery, particularly bilateral sagittal split osteotomy (BSSO), remains the most effective intervention, achieving approximately 3.4 mm of overbite reduction with stable long-term occlusal outcomes. Surgical correction is essential in cases in which orthodontic force systems alone are insufficient to resolve vertical discrepancies.

Each treatment modality exerts unique orthodontic forces in terms of direction, magnitude, and anchorage requirement. This underscores the importance of selecting treatment modalities based on a careful balance between clinical effectiveness and potential side effects. Aligning force systems with individual clinical objectives is essential for achieving predictable, aesthetic, and stable outcomes in adult deep bite correction.

4.2. Biomechanical Comparison of TADs and Intrusion Arches in Inclination Control

A deeper analysis comparing TADs and intrusion arches, centred on the ratio of incisor proclination to intrusion, highlights clear distinctions in biomechanical efficiency. While both approaches are capable of producing substantial maxillary incisor intrusion, their impact on inclination varies considerably.

The most favourable proclination-to-intrusion ratios were observed in two-TAD configurations placed distal to the lateral incisors, as reported by Raj et al. (2015) and Namrawy et al. (2019), with ratios of 0.6°/mm and 0.8°/mm, respectively. These results reflect highly controlled tooth movement with minimal undesired labial tipping. In contrast, intrusion arch mechanics demonstrated notably higher proclination per unit of intrusion. Even in its most efficient form, the Burstone arch (Raj et al., 2015) resulted in a 2.5°/mm ratio, over four times greater than that of the most favourable TAD setup. The Ricketts utility arch (Goel et al., 2014) showed the least biomechanical efficiency, with a 5.1°/mm ratio, indicating a high degree of proclination relative to the achieved intrusion.

Interestingly, the same 2.5°/mm ratio was observed in both the Burstone arch (Raj et al., 2015) and the one-TAD configuration positioned between the central incisors (Vela-Hernández et al., 2020). However, the absolute values differed significantly. The one-TAD group showed greater proclination (14.3°) and more intrusion (5.7 mm) than the Burstone arch (10.9°, 4.3 mm). This comparison underscores that while two modalities may yield similar ratios, their clinical implications differ based on the magnitude of movement and the associated side effects.

These findings suggest that absolute anchorage, as provided by TADs, allows force application closer to the centre of resistance of the anterior segment, facilitating more bodily intrusion with minimal tipping. In contrast, posteriorly anchored intrusion arches create a longer lever arm and a larger moment, increasing the risk of labial proclination. Within TAD protocols, the use of dual implants placed distal to the lateral incisors consistently produced more favourable biomechanical outcomes than single TADs placed between the central incisors, demonstrating the importance of implant position and configuration in torque management.

Clinically, this distinction holds particular relevance in adult orthodontics, where control over incisor inclination is critical not only for aesthetics and facial harmony but also for maintaining periodontal health and treatment stability. While intrusion arches remain a viable option, particularly when proclination is either desirable or acceptable, TADs, especially dual configurations, offer a more predictable and refined approach when maintaining or correcting incisor torque is a primary treatment objective.

4.3. Biomechanical Determinants of EARR: Intrusion Rate and Proclination

In relation to external apical root resorption (EARR), the literature consistently identifies it as a common biological consequence of maxillary incisor intrusion in adult deep bite treatment. The extent of EARR appears to be strongly influenced by two modifiable mechanical factors, the intrusion rate, expressed as millimetres per month, and the degree of incisor proclination. A consistent trend emerged showing that greater intrusion rates tend to correspond with more extensive root resorption, particularly when combined with increased tipping of the incisor. TADs and intrusion arches alike demonstrated this correlation, confirming that the magnitude of force and its direction are critical in determining biological responses at the root apex.

While the association between higher intrusion rates and greater external apical root resorption was consistent across studies, a few exceptions highlight the complexity of the underlying biomechanics. The findings of this thesis support the conclusion that both the intrusion rate and the amount of incisor tipping significantly influence the degree of EARR, where greater intrusion per month and increased proclination are generally associated with more resorption. However, in the study by Aras et al. (2016), the posterior TAD group, despite exhibiting greater proclination (14.8°), demonstrated less EARR than the anterior TAD group. This was attributed to differences in force vector direction. The posterior TADs, placed between the second premolars and first molars, applied a more horizontal force that may have allowed the incisor roots to retract into the spongiosa, a region of less dense bone, thus reducing apical stress. In contrast, the anterior TADs, located between the lateral incisors and canines, generated a more vertical force, contributing to a higher intrusion rate and greater root compression.

Similarly, Manikandan et al. (2024) illustrated that while intrusion of the maxillary central and lateral incisors was greater in the two-TAD group, the pattern of EARR varied with anchorage position. Specifically, central incisor resorption was greater in the one-TAD group, where the miniscrew was placed between the central incisors. Conversely, lateral incisor resorption was greater in the two-TAD group, where the screws were placed distal to the lateral incisors. This suggests that EARR may be more pronounced in the teeth closest to the site of force application, highlighting the impact of TAD placement location. Moreover, no significant differences were observed between one- and two-TAD setups in terms of changes in incisor inclination, labial bone thickness, or buccal alveolar crest height, further underscoring that localised stress, rather than overall tipping, is a key factor influencing EARR patterns.

Moreover, Vela-Hernández et al. (2020) provide a compelling illustration of this relationship. Their study reported that the two-TAD group had the highest intrusion rate among all studies (1.34 mm/month), accompanied by 11.5° of proclination and corresponding EARR of 2.11 mm in the central incisor. Meanwhile, the one-TAD group exhibited the greatest degree of proclination (14.3°) and the highest amount of root resorption (2.20 mm in CI), despite a lower intrusion rate (0.93 mm/month). These findings underscore the dual influence of both intrusion rate and tipping on the extent of EARR and further highlight how each mechanical variable, force magnitude, direction,

and anchorage method, can independently or synergistically contribute to biological side effects during intrusion.

These findings emphasise that, beyond the basic metrics of intrusion rate and proclination, the detailed design of the force system, including its vector direction, anchorage location, and spatial interaction with the alveolar bone, plays a pivotal role in determining the biological response at the root apex.

4.4. Clinical Considerations Based on Findings

These findings have significant clinical implications. They emphasise the importance of carefully selecting treatment modalities based on both effectiveness and biological risk profiles. The biomechanics of each modality should be matched to the patient's clinical and aesthetic needs. TADs and lingual appliances are best suited for patients requiring controlled intrusion with minimal tipping. In contrast, intrusion arches may be appropriate when moderate proclination is acceptable or beneficial. The proclination-to-intrusion ratio can serve as a practical guideline for clinicians aiming to anticipate and manage tipping. Moreover, understanding that higher intrusion rates and greater proclination increase the risk of EARR necessitates more cautious treatment protocols. This includes applying lighter forces, extending treatment duration when necessary, and conducting routine radiographic monitoring to detect early signs of root resorption. Comprehensive patient education and informed consent are also essential, particularly in adult cases in which intrusion is indicated.

4.5. Limitations of the Study

This review is subject to several methodological limitations. Foremost, the absence of long-term follow-up data in most included studies restricts the ability to assess the post-treatment stability of deep bite correction. As a result, the durability of outcomes across different treatment modalities remains uncertain.

Although a few studies provide insights into relapse tendencies in adult patients, the evidence is limited and context-specific. For example, Varlik et al. (2013) reported minimal relapse in overbite (0.8 mm) and overjet (0.4 mm) over a five-year period in adults treated with utility arches, suggesting that stable outcomes are achievable with appropriate mechanics. However, the small sample size and narrow treatment focus limit the generalisability of these findings. Huang et al. (2012) emphasised that patients with more severe pretreatment overbite are particularly prone to relapse, especially when skeletal modifications are no longer possible. Their study also noted that up to 80% of post-treatment changes occur within the first two years, highlighting the critical importance of the early retention phase and the need for individualised retention protocols in adult cases.

Additionally, heterogeneity in participant selection, such as variations in the age criteria for defining adults, baseline skeletal and dental characteristics, and diagnostic thresholds for deep bite, complicates direct comparisons between study populations. Inconsistencies in treatment duration across studies further hinder the evaluation of therapeutic efficiency, as shorter or longer intervention periods may influence outcomes independent of the treatment modality. Finally, the lack of standardised radiographic measurement protocols, including differences in imaging techniques and cephalometric analysis software, introduces potential variability in data interpretation, limiting the precision of cross-study comparisons.

Collectively, these limitations underscore the need for future research that incorporates standardised diagnostic criteria, consistent measurement protocols, and extended long-term follow-up. Such efforts will enable more robust comparisons, support stronger clinical conclusions, and enhance the development of evidence-based treatment planning for adult deep bite correction.

5. Conclusion

Various methods have been proven effective for deep bite correction in adults, including fixed appliances, intrusion arches, miniscrews (TADs), clear aligners, bite turbos, functional appliances, and surgical interventions.

Choosing the most appropriate approach requires a clear understanding of the biomechanical forces each method applies and how they align with the patient's specific malocclusion. Importantly, most intrusion-based treatments are accompanied by incisor proclination, making the proclination-to-intrusion ratio a valuable metric in clinical decision-making. Among the studied modalities, two-TAD configurations consistently demonstrated the most efficient ratios, supporting their clinical value in managing deep bite with minimal tipping.

As deep bite correction typically involves both incisor intrusion and associated proclination, it is important to recognise that these movements carry a biological cost, specifically, an increased risk of external apical root resorption (EARR). Evidence consistently indicates that higher intrusion rates and greater degrees of proclination are linked to more severe EARR. Therefore, these risks must be carefully considered and closely monitored throughout treatment to ensure both clinical effectiveness and long-term biological safety.

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References

Alhammadi, M. S., Halboub, E., Fayed, M. S., Labib, A., & El-Saaidi, C. (2018). Global distribution of malocclusion traits: A systematic review. *Dental Press Journal of Orthodontics*, *23*(6), 40.e1–40.e10. doi:10.1590/2177-6709.23.6.40.e1-10.onl

Al-Zoubi, E. M., & Al-Nimri, K. S. (2022). A comparative study between the effect of reverse curve of Spee archwires and anterior bite turbos in the treatment of deep overbite cases. *The Angle Orthodontist*, *92*(1), 36–44. doi:10.2319/020921-117.1

Aras, I., & Tuncer, A. V. (2016). Comparison of anterior and posterior mini-implant-assisted maxillary incisor intrusion: Root resorption and treatment efficiency. *The Angle Orthodontist*, *86*(5), 746–752. doi:10.2319/085015-571.1

Cançado, R. H., Janson, G., Tompson, B., Alvares, J. C. de C., Valarelli, F. P., & Freitas, K. M. S. (2021). Treatment effects of the Herbst appliance in Class II malocclusion patients after the growth peak. *European Journal of Dentistry*, *15*(1), 39–46. doi:10.1055/s-0040-1715789

Daokar, S., & Agrawal, G. (2016). Deep bite its etiology, diagnosis and management: A review. *Journal of Orthodontics & Endodontics*, *2*(4). doi:10.21767/2469-2980.100029

de Almeida, M. R., Marçal, A. S. B., Fernandes, T. M. F., Vasconcelos, J. B., de Almeida, R. R., & Nanda, R. (2018). A comparative study of the effect of the intrusion arch and straight wire mechanics on incisor root resorption: A randomized, controlled trial. *The Angle Orthodontist*, *88*(1), 20–26. doi:10.2319/06417-424r

El Namrawy, M. M., Sharaby, F. E., & Bushnak, M. (2019). Intrusive arch versus miniscrew-supported intrusion for deep bite correction. *Open Access Macedonian Journal of Medical Sciences*, *7*(11), 1841–1846. doi:10.3889/oamjms.2019.332

Fujiyama, K., Kera, Y., Yujin, S., Tanikawa, C., Yamashiro, T., Guo, X., Ni, A., & Deguchi, T. (2022). Comparison of clinical outcomes between Invisalign and conventional fixed appliance therapies in adult patients with severe deep overbite treated with nonextraction. *American Journal of Orthodontics and Dentofacial Orthopedics*, *161*(4), 542–547. doi:10.1016/j.ajodo.2020.08.023

Goel, P., Tandon, R., & Agrawal, K. K. (2014). A comparative study of different intrusion methods and their effect on maxillary incisors. *Journal of Oral Biology and Craniofacial Research*, *4*(3), 186–191. doi:10.1016/j.jobcr.2014.11.007

Henick, D., Dayan, W., Dunford, R., Warunek, S., & Al-Jewair, T. (2021). Effects of Invisalign (G5) with virtual bite ramps for skeletal deep overbite malocclusion correction in adults. *The Angle Orthodontist*, *91*(2), 164–170. doi:10.2319/072220-646.1

Huang, G. J., Bates, S. B., Ehlert, A. A., Whiting, D. P., Chen, S. S.-H., & Bollen, A.-M. (2012). Stability of deep-bite correction: A systematic review. *Journal of the World Federation of Orthodontists*, *1*(3), e89–e86. doi:10.1016/j.ejwf.2012.09.001

Kang, J., Jeon, H. H., & Shahabuddin, N. (2024). Does aligner refinement have the same efficiency in deep bite correction?: A retrospective study. *BMC Oral Health*, *24*(1), 338. doi:10.1186/s12903-024-04099-8

Manikandan, M., Das, S. K., Barik, A. K., Raj, S. C., Mishra, M., Rath, S. K., & Sah, S. (2024). Evaluation of dentoalveolar changes following maxillary incisor intrusion with one vs two anterior miniscrews in subjects with gummy smile: A randomized clinical trial. *The Angle Orthodontist*, *94*(5), 522–531. doi:10.2319/121323-825.1

Mohanty, P., Prabhakar, R., Karthikeyan, M. K., Saravanan, R., & Vikram, N. R. (2015). Comparison of intrusive effects of mini screws and Burstone intrusive arch: A radiographic study. *Journal of Research and Advancement in Dentistry*, *4*(2), 102–109. [uncertain: DOI match] doi:10.7860/jcdr/2013/7411.3869

Ölmez Gürlen, S., & Aras, I. (2016). Comparison of the treatment effects of two intrusive mechanics: Connecticut intrusion arch and mini-implant. *Turkiye Klinikleri Journal of Dental Sciences*, *22*(3), 195–201. doi:10.5336/dentalsci.2016-52123

Pamukçu, H., & Özsoy, Ö. P. (2021). A comparison of treatment results of adult deep-bite cases treated with lingual and labial fixed appliances. *The Angle Orthodontist*, *91*(5), 590–596. doi:10.2319/011021-29.1

Paunonen, J., Helminen, M., & Peltomäki, T. (2018). Long-term stability of mandibular advancement with bilateral sagittal split osteotomy. *Journal of Cranio-Maxillofacial Surgery*, [missing: Volume], [missing: Pages]. doi:10.1016/j.jcms.2018.05.023

Rozzi, M., Tiberti, G., Mucedero, M., & Cozza, P. (2022). Leveling the curve of Spee: Comparison between continuous archwire treatment and Invisalign system: A retrospective study. *American Journal of Orthodontics and Dentofacial Orthopedics*, *162*(5), 645–655. doi:10.1016/j.ajodo.2021.06.020

Shahabuddin, N., Kang, J., & Jeon, H. H. (2023). Predictability of the deep overbite correction using clear aligners. *American Journal of Orthodontics and Dentofacial Orthopedics*, *163*(6), 793–801. doi:10.1016/j.ajodo.2022.07.019

Shakhtour, F., & Al-Nimri, K. (2025). Comparison between effects of reverse curve of Spee nickel titanium archwire and stainless steel archwires with and without torque on the lower incisors in deep overbite treatment: a randomized control study. *The Angle Orthodontist*, *95*(1), 27–34. doi:10.2319/051524-376.1

Supanich, P., Thongudomporn, U., & Viteporn, S. (2025). Dental arch dimensional changes in deep bite adults treated with orthodontic fixed appliances in conjunction with maxillary incisor vs. canine bite turbos during the levelling and aligning phase: a randomized clinical trial. *Clinical Oral Investigations*, *29*(1), 46. doi:10.1007/s00784-024-06145-9

Varlık, K., Onur Alpakan, S., & Türköz, Ö. (2013). Deepbite correction with incisor intrusion in adults: a long-term cephalometric study. *American Journal of Orthodontics and Dentofacial Orthopedics*, *144*(3), 414–419. doi:10.1016/j.ajodo.2013.04.014

Vela-Hernández, A., Gutiérrez-Zubeldia, L., López-García, R., García-Sanz, V., Paredes-Gallardo, V., Gandía-Franco, J. L., & Lasagabaster-Latorre, F. (2020). One versus two anterior miniscrews for correcting upper incisor overbite and angulation: A retrospective comparative study. *Progress in Orthodontics*, *21*, 34. doi:10.1186/s40510-020-00336-2

Verma, P., & Jain, R. K. (2020). Intrusion effects on maxillary anteriors using mini implant anchorage and K-Sir loop in subjects with deep overbite–A cohort study. *Journal of Clinical and Diagnostic Research*, *14*(12), 21–25. doi:10.7860/jcdr/2020/46175.14316

Watted, N., Lone, I. M., Zohud, O., Midlej, K., Proff, P., & Iraqi, F. A. (2023). Comprehensive deciphering the complexity of the deep bite: Insight from animal model to human subjects. *Journal of Personalized Medicine*, *13*(10). doi:10.3390/jpm13101472